Economic Impact of Climate Variability and Change on The California Water System

California Climate Change Center

Research Questions

- How reliable is California's water supply?
- What is the cost of supply unreliability for agricultural, urban, hydropower, and in-stream users?
- How will climate change affect future supply reliability for different users?
- What are policy options for mitigating these adverse impacts?

Berkeley Water Group

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Some Distinctive Features

- Spatial scale is the individual water districts, both agricultural and urban.
  - Even neighboring districts are quite heterogeneous with regard to key variables. DAU and DSA spatial scales are too large and miss these differences.
- Strong institutional focus integrating hydrology, water rights, and economics.
- Baseline is 1980 - 2003. Need to understand how the present system works before start layering on (i) evolution of the system over 2005-2100, and (ii) climate change.

Distinctive Features #2

- Focus explicitly on reliability as key mediating variable for many water users in in California.
- *Ex ante* expectation of obtaining water during the summer is crucial determinant of
  - agricultural uses (by irrigation districts),
  - urban uses (by regional and municipal water agencies)
  - environmental uses (in-stream flows).
- Existing hydrologic and economic models treat uncertainty just in terms of *ex post* outcomes.

Distinctive Features # 3

- Strong positive rather than normative focus – understand how system works now and will respond in future, as opposed to how it *ought to* work or respond.
- Use regression analysis combined with micro-data to model/summarize functioning of hydrologic & economic systems

Overall Approach

- Measure current reliability of supply for main agricultural & urban water districts
- Measure economic value of reliability based on inter-district variation in supply reliability
- Analyze trends that may affect future supply reliability and its economic value
- Identify impact of climate change on supply reliability
- Estimate cost of climate-induced unreliability

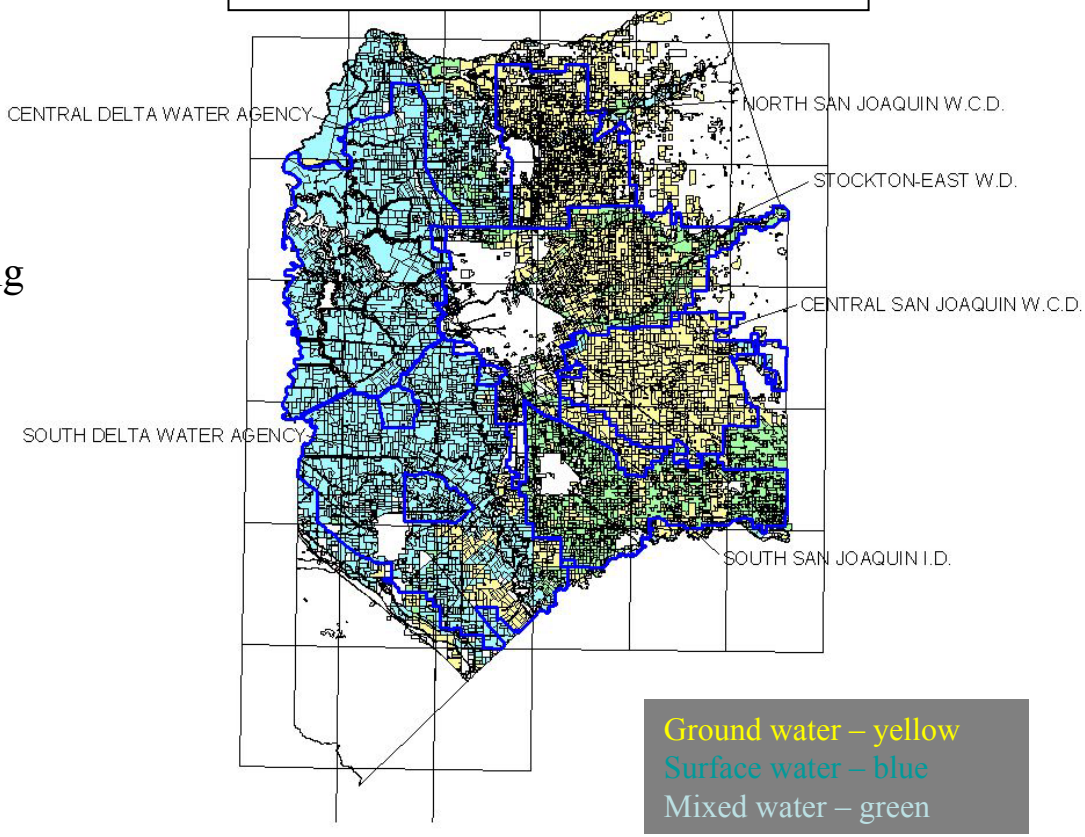
Research Tasks

- Create two databases covering agricultural and urban water districts in California
- Develop measures of supply reliability
- Econometric analyses of the value of supply reliability for ag & urban districts
- Project future baseline for ag & urban uses
- Assess economic impacts of climate change scenarios and policy interventions

Data Collection--Water District Variation

- Supply uncertainty should be considered at the district level
  - Supply uncertainty varies across districts because of the following variables:
    - Water sources and deliveries
    - Rights
    - Reliability of supply
    - Ex-ante probability distribution of obtaining water when needed

San Joaquin County Districts and Water Source (from DWR)



Agricultural District Data Collection

- Currently there is a lack of inclusive statewide data set covering characteristics of water districts and cropping outside of districts.
- We have collected data to measure both water supply reliability and the economic value of reliability.
  - To measure water supply reliability we have collected:
    - Deliveries for project districts spanning 20 years
    - Supply forecasts for project districts spanning 20 years
    - Some water rights information
    - Water source information and electricity use data related to groundwater pumping.
  - To measure the economic value of reliability we have collected:
    - Land values
    - Water prices
    - Water transfers for many years
    - Cropping by district

Variables # 1

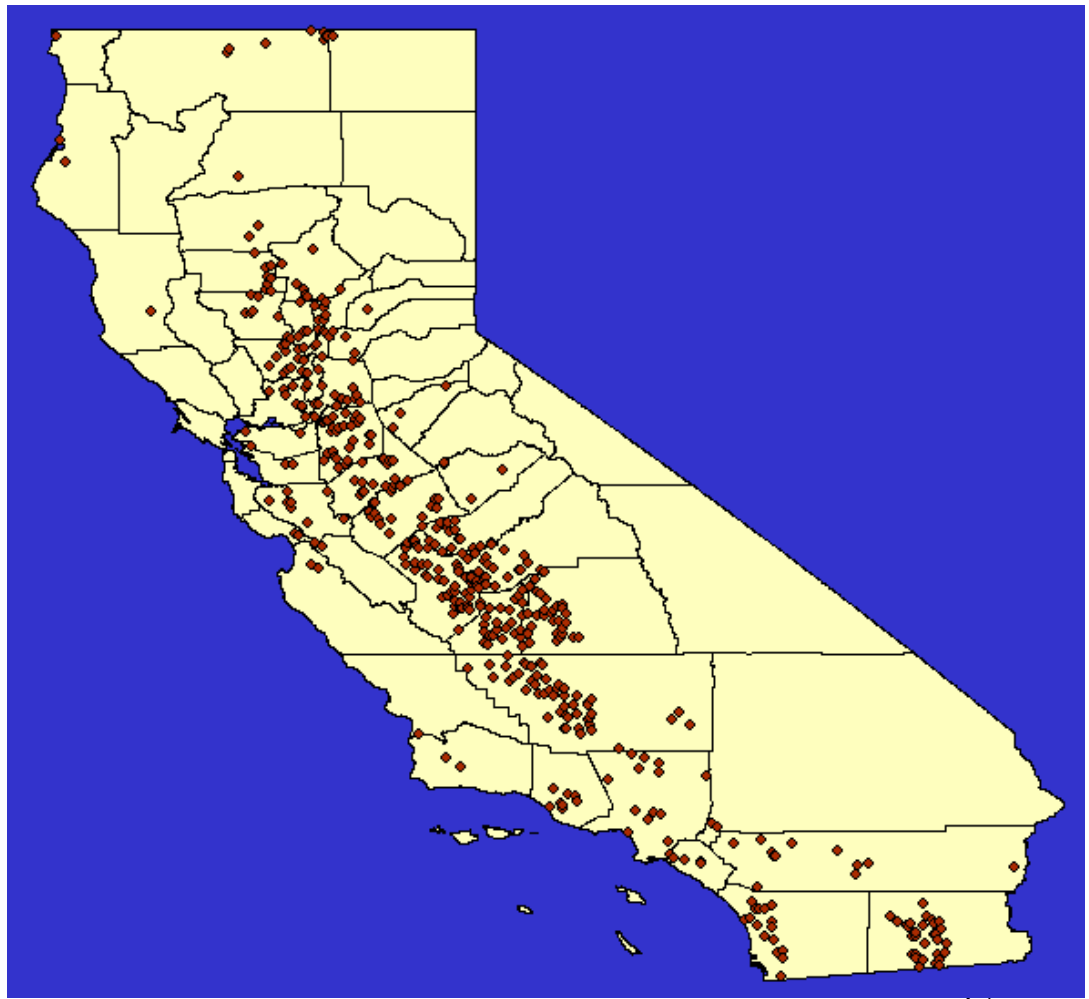
- Climatic Data
  - PRISM 100-year run of minimum and maximum monthly temperatures as well as precipitation
  - 2.5 x 2.5 mile grid of the United States
  - We use the 4 grid points surrounding each farm
- Population pressure
  - Population in all of the 7049 Census tracts in California
  - Weighted by the squared inverse of the distance to farm
- Soil Data
  - STATSGO soil survey

Agricultural Variables #2

- Groundwater Data
  - Constructed from more than 16,000 well observations
- Surface Water Rights
  - Entitlements from Central Valley Project Operations Report
  - Entitlements from ACWA (Association of California Water Agencies) database
  - District area from GIS boundaries and/or ACWA
  - Water rights are measured in AF per acre
- Water Prices
  - Obtained from ACWA and Irrigation Water Rates Manual

Impact of water on farmland values

- June Agricultural Survey
  - Land value data
  - Farm-level observations
  - Identify corresponding irrigation districts
  - Combine with district-level information



Measuring supply reliability

- Supply reliability is measured in terms of exceedance probabilities of deliveries.
- Can use historic delivery data to measure historic reliability but need to use an operations model to assess reliability under climate change-scenarios.
- Such a model should have the following characteristics:
  - Coverage of all agricultural districts in Central Valley and the major urban areas in southern and northern California
  - Flexibility in terms of hydrologic inputs (e.g. use of synthetic hydrology)
  - Flexibility in terms of reservoir operations
- Current available models: CALSIM-II does not presently meet all these requirements.
- We are hoping to supplement CALSIM with some alternative models.

Urban Water Data Collection

- Household level water use data from a variety of urban water agencies in established & growing urban and suburban areas around California
- Data on water/sewer rates & conservation programs, and water supply infrastructure
- Housing and demographic data by census tracts
- House attribute data from sales data
- Daily climate data

Urban water analysis

- Estimate long- and short-run elasticities of demand for water, and long-and short-run shortage costs
- Model location of residential growth
- Combine new housing location with residential water (and energy) demand by housing vintage, housing characteristics, demography, climate, and pricing/conservation policies
- Generate baseline 2100 residential water/energy demands

Where we are heading

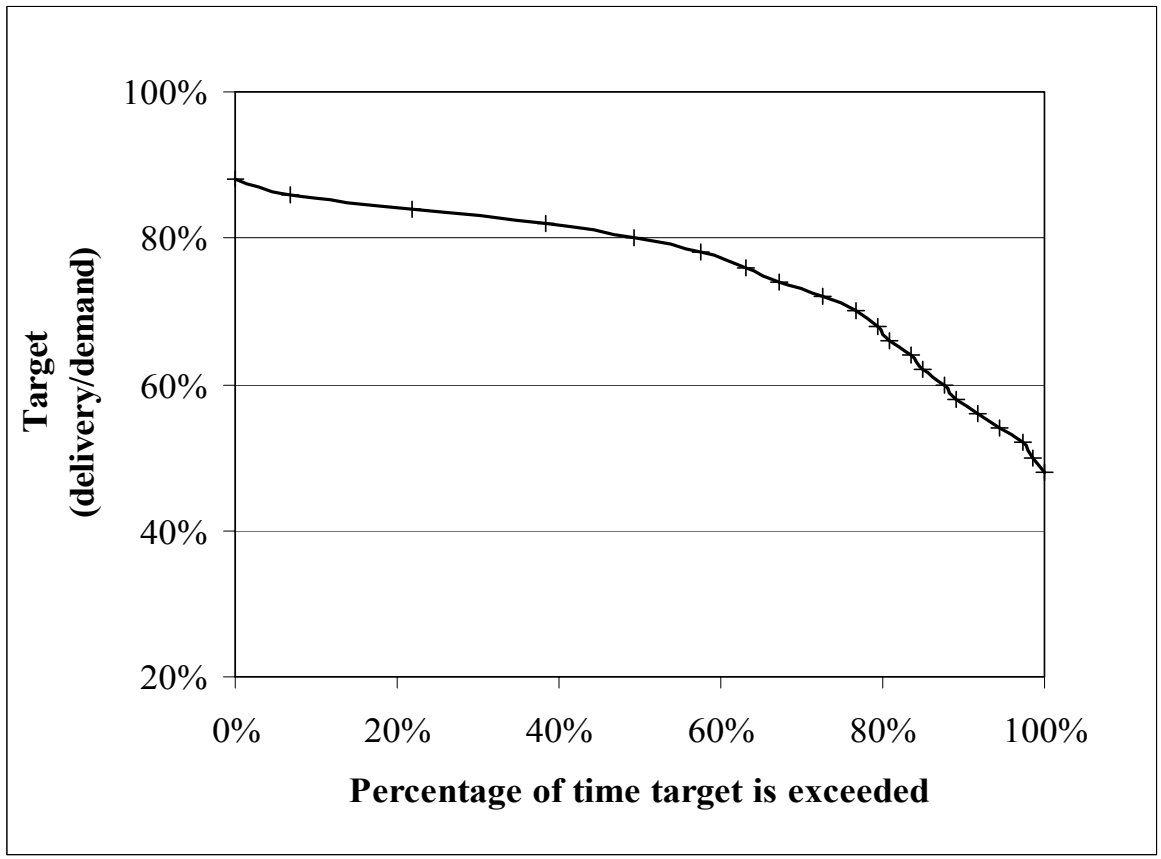
- Agricultural & urban demands for water vary with temperature
- Urban demand varies with location and vintage (new *vs* old suburbs)
- Distinguish short *vs* long-run urban demand
- Distinguish short term vs long-run water market transactions
- Account for varying water rights seniority

What We Know So Far

1. District level variation in supply reliability
2. Reliability is capitalized in land value
3. Asymmetric implications of change in temperature vs precipitation
4. Potential net reduction in available water for California
5. Poses grave challenge for management of California water system

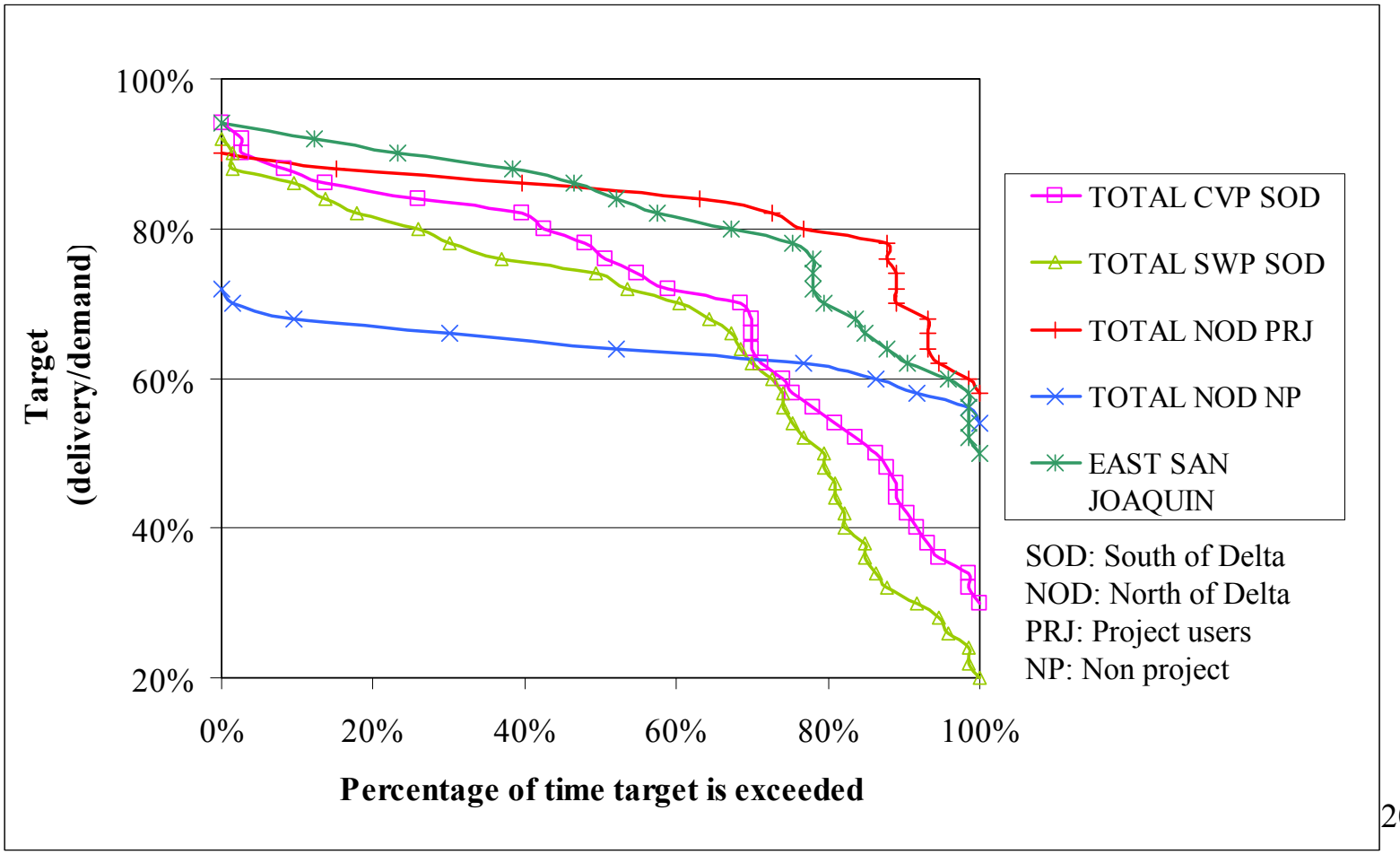
1. Current climate water supply reliability using CALSIM-II data

Figure shows percent of time a given delivery target is met considering the demands of the users in the Central Valley represented in CALSIM-II:



1. Current District level variation in supply reliability

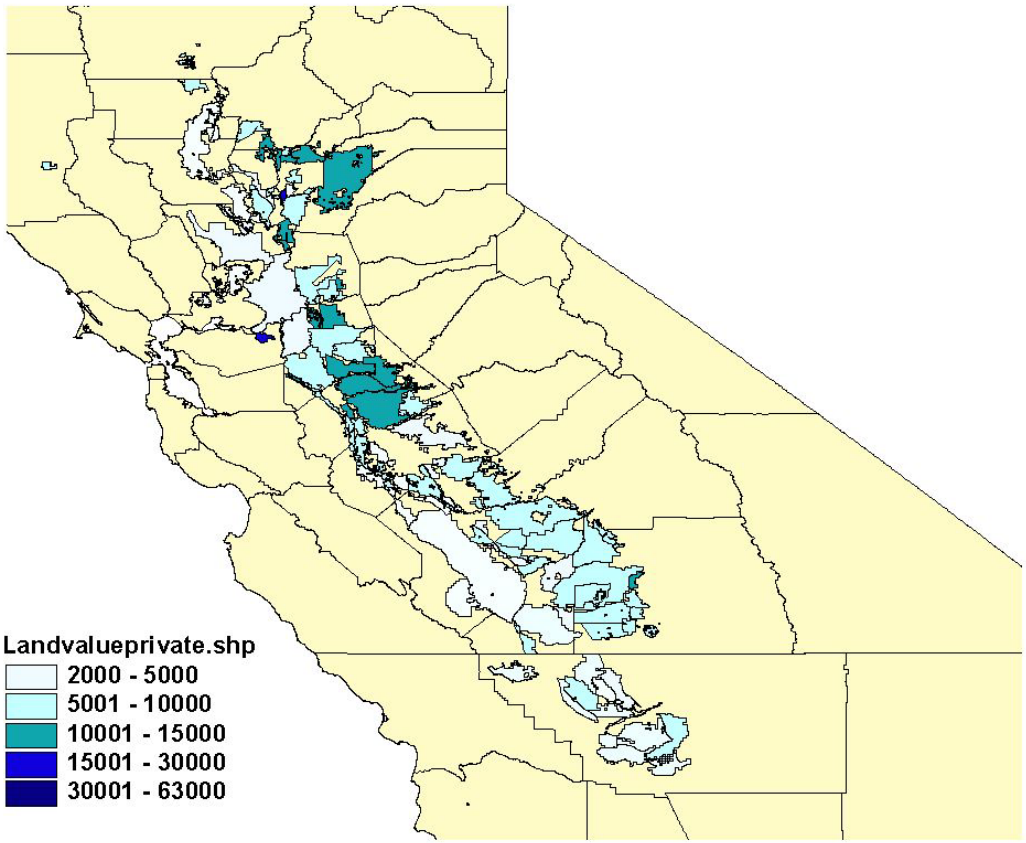
If we break the CALSIM analysis down by major group users we see that reliability varies greatly. We expect even higher variations at the individual district level but spatial resolution of CALSIM-II doesn't permit this.



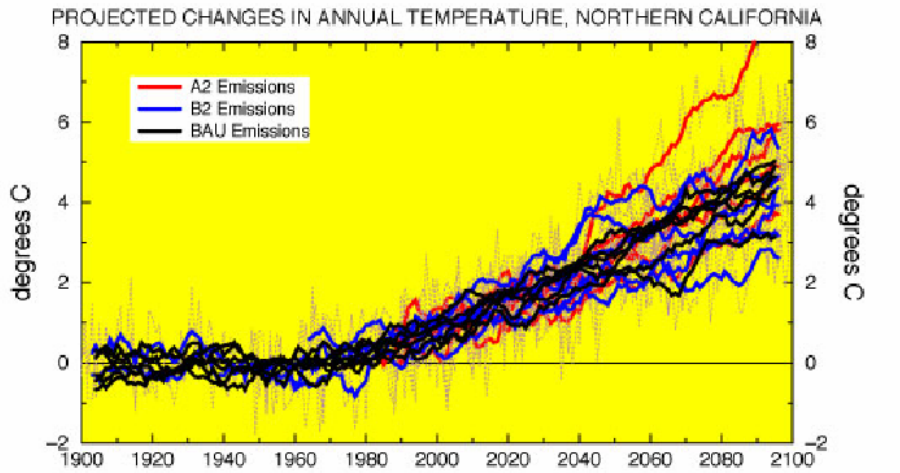
2. Capitalization of Water Supply Reliability

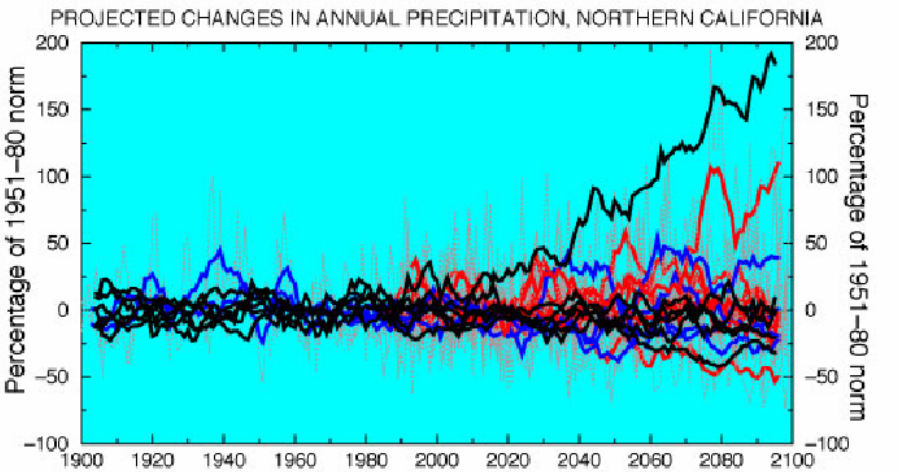
- Farm level water costs are capitalized in farmland values
- Seniority of district water rights is capitalized in farmland values
- Now investigating how district level water supply reliability is capitalized in farmland values

2. Capitalization of Water Reliability



3. Asymmetry between temperature and precipitation forecasts





Clearly warmer

Not certain about precipitation

Most likely: earlier runoff

Dettinger, 2004

3. Asymmetry between temperature and precipitation

- Consensus that there would be an increase in temperature but no clear trend in precipitation.
- HADCM3 & PCM3 show higher temperature increase and less precipitation for California than HADCM2 & PCM2
- Where there is an increase in precipitation, it appears not to occur in April-September

4. Implications for water supply: reduction in effective supply & increase in demand

- About 75% of all water use in California occurs April-September
- About 80% of all water use in California in April-September is outdoor irrigation by households and farmers, and is temperature sensitive; higher temperatures will increase this demand for water
- Any significant reduction in snow pack as of April 1 means a loss of natural storage
- An increase in precip in April-September is not likely
- Consequently, increased shortage of water with existing storage

5. Prospect of significant disruption to California water – management challenges

- Management of existing reservoirs becomes even more crucial (less snowpack, more extreme events)
- Users with good access to storage likely to gain
- Users with junior water rights to April-September stream flow might be hurt
- More stress on groundwater resources
- Management of water rights becomes more crucial, especially for water projects, water markets

STAY TUNED!